Amec in July 2014 conducted a field test of anaerobic biodegradation to support the anaerobic EBR modeling that was performed as part of the ST012 RD/RAWP due to the fact that significant assumptions were made in the analysis (Addendum #2, Appendix C, page 1-1). This field test was comprised of two push-pull tests performed at existing wells W-11 and W-30, both of which are completed in the lower saturated zone, and both of which were known to be impacted by LNAPL. The purpose of the field test was to determine sulfate utilization rates. Pumping rates during the extraction phase from W-30 could not be sustained due to well fouling, and the limited amount of groundwater extracted from W-30 'did not provide a sufficient data set to estimate sulfate utilization' (lines 475-476). At W-11, sulfate concentrations increased during the pull portion of the test, which 'indicate that background groundwater sulfate concentrations were being pulled into the well and prevent the accurate estimation of sulfate utilization' (lines 477-478).

Instead, sulfate utilization was estimated from the shut-in portion of the test. Data presented from W-11 show that the TPH and benzene concentrations remained essentially constant during the shut in period (Table 2-1), while normalized sulfate concentrations were greater than the normalized tracer concentrations during most of the shut in phase of the test (Graph 3-4). Thus, very little sulfate utilization was demonstrated from the results at this well.

Data from W-30 show that the DRO and TPH concentrations increased substantially during the shut-in period of the test and benzene concentrations approximately doubled (Table 2-2), while the sulfate concentration decreased exponentially with time (Table 2-6). While the results at this well showed sulfate utilization during the shut in period (Graph 3-5), the results did not demonstrate that TPH or benzene were consumed by the sulfate that was utilized.

Based on the conflicting data obtained during the field test, it is recommended that further field and/or laboratory testing be completed. In light of the inconclusive results on benzene degradation accompanying sulfate utilization, the first objective of the additional site specific testing should be demonstrating that the sulfate-reducing microbial consortia at this site is capable of degrading benzene, and if so, what conditions are necessary to maximize the degradation rate. The extremely high sulfate injection rate proposed in Addendum #2 should be investigated in the laboratory to determine what the 'shock loading' of sulfate will do to the microbial populations, and the geochemical changes this sulfate addition will cause. Laboratory experiments could determine if the existing microbial system is deficient in sulfate, and if so, the amount of sulfate needed to maximize degradation rates. Based on what is learned from the laboratory experiments, a field test can be designed that will allow estimation of field degradation rates of benzene (if benzene is found to degrade), using a flow-through field setup rather than a push-pull test. Estimates of benzene degradation derived from the field test can be used in the model to estimate treatment times, although it must be kept in mind that, "***Anaerobic bioremediation is still not thoroughly understood, especially under field conditions, making clean-up times difficult to predict***" (ESTCP, 1999). The presence of significant LNAPL at this site and low permeability zones that are known to contain LNAPL will limit the biodegradation rate (ESTCP, 1999, page 6).

The laboratory and field tests would also be used to determine the sulfate dosing required to degrade benzene. According to the referenced ESTCP document, "***Ground water contaminated***

from gasoline contains not only BTEX compounds, but many other gasoline components as well. At the Seal Beach site, much of the injected nitrate and sulfate was utilized by bacteria to degrade non-BTEX hydrocarbons. This makes it difficult to predict the amount of electron acceptor(s) that will be needed for complete BTEX removal." In field experiments at a gasoline spill site, Reinhard et al. (ES&T, 31(1):28-36, 1997) found that only 13 to 40% of the sulfate consumed was used to degrade BTEX. However, review of Addendum #2 shows that the current implementation plan for EBR at ST012 estimates the sulfate dosage required by assuming that only enough sulfate is needed to degrade BTEX, disregarding the other components of the jet fuel, and does not include BTEX in the LPZ. Thus, the planned injection of 870 tons of sulfate – as large as this amount is – is still extremely short of what would be required to degrade the BTEX at ST012.